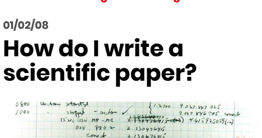
01/02/08

How do I write a scientific paper?



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Tips on how to present the results of a study, and give it the best chance of publication.

Adapted with permission from a text developed by the Applied Ecology Research Group at the University of Canberra Australia, and prepared with the aid of 'How to Write and Publish a Scientific Paper' *by Robert Day (ISI Press, Philadelphia, 1979).*

A scientific paper is a written report describing original research results whose format has been defined by centuries of developing tradition, editorial practice, scientific ethics and the interplay with printing and publishing services. The result of this process is that virtually every scientific paper has a title, abstract, introduction, materials and methods, results and discussion.

It should, however, be noted that most publications have rules about a paper's format: some divide papers into these or some of these sections, others do not, and the order may be different in different publications. So be prepared to revise your paper in to a publication's format when you are ready to submit.

One general point to remember is the need to avoid jargon and acronyms as much as possible. A second is the fact that some journals like papers to be written in the active voice - i.e. "we carried out a test to..." rather than " test was carried out to..." — but that this is not always the case.

Title

A title should be the fewest possible words that accurately describe the content of the paper. Omit all waste words such as "A study of ...", "Investigations of ...", "Observations on ...", etc. Indexing and abstracting services depend on the accuracy of the title, extracting from it keywords useful in cross-referencing and computer searching.

An improperly titled paper may never reach the audience for which it was intended, so be specific. If the study is of a particular species or chemical, name it in the title. If the study has been limited to a particular region or system, and the inferences it contains are similarly limited, then name the region or system in the title.

Keyword list

The keyword list provides the opportunity to add keywords, used by the indexing and abstracting services, in addition to those already present in the title. Judicious use of keywords may increase the ease with which interested parties can locate your article.

Abstract

A well-prepared abstract enables the reader to identify the basic content of a document quickly and accurately, to determine its relevance to their interests, and thus to decide whether to read the document in its entirety. The abstract concisely states the principal objectives and scope of the investigation where these are not obvious from the title. More important, it concisely summarises the results and principal conclusions. Do not include details of the methods used unless the study is methodological, i.e. primarily concerned with methods.

The abstract must be concise; most journals specify a length, typically not exceeding 250 words. If you can convey the essential details of the paper in 100 words, do not use 200. Do not repeat information contained in the title. The abstract, together with the title, must be self-contained as it is published separately from the paper in abstracting services such as Biological Abstracts or Current Contents. Omit all references to the literature and to tables or figures, and omit obscure abbreviations and acronyms even though they may be defined in main body of the paper.

Introduction

The introduction begins by introducing the reader to the pertinent literature. A common mistake is to introduce authors and their areas of study in general terms without mention of their major findings. For example: "Parmenter (1976) and Chessman (1978) studied the diet of *Chelodina longicollis* at various latitudes and Legler (1978) and Chessman (1983) conducted a similar study on *Chelodina expansa*" compares poorly with: "Within the confines of carnivory, *Chelodina expansa* is a selective and specialised predator feeding upon highly motile prey such as decapod crustaceans, aquatic bugs and small fish (Legler, 1978; Chessman, 1984), whereas *C. longicollis* is reported to have a diverse and opportunistic diet (Parmenter, 1976; Chessman, 1984)". The latter is a far more informative lead-in to the literature, but more importantly it will enable the reader to clearly place the current work in the context of what is already known.

Try to introduce references so they do not interfere with the flow of your argument: first write the text without references so that it reads smoothly, then add in the references at the end of sentences or phrases so they do not interrupt your flow. Note that not all journals use author's names in references some use numbers in the text with a list of citations at the end of the article. Check the publication's style when you are ready to submit your paper.

An important function of the introduction is to establish the significance of your current work: Why was there a need to conduct the study? Having introduced the pertinent literature and demonstrated the need for the current study, you should state clearly the scope and objectives.

Avoid a list of points or bullets; use prose.

The introduction can finish with the statement of objectives or, as some people prefer, with a brief statement of the principal findings. Either way, the reader must have an idea of where the paper is heading to follow the development of the evidence.

Materials and methods

The main purpose of the 'Materials and Methods' section is to provide enough detail for a competent worker to repeat your study and reproduce the results. The scientific method requires that your results be reproducible, and you must provide a basis for repetition of the study by others.

Equipment and materials available off the shelf should be described exactly (e.g. Licor underwater quantum sensor, Model LI 192SB) and sources of materials should be given if there is variation in quality among supplies. Modifications to equipment or equipment constructed specifically for the study should be carefully described in detail. The method used to prepare reagents, fixatives, and stains should be stated exactly, though often reference to standard recipes in other works will suffice.

The usual order of presentation of methods is chronological. However, related methods may need to be described together and strict chronological order cannot always be followed. If your methods are new (i.e. unpublished), you must provide all the detail required to repeat them. However, if a method has been previously published, only the name of the method and a literature reference need be given.

Be precise in describing measurements and include errors of measurement. Ordinary statistical methods should be used without comment; advanced or unusual methods may require a literature citation. Show your materials and methods section to a colleague. Ask if they would have difficulty in repeating your study.

Results

are central in this section. Present the data, digested and condensed, with important trends extracted and described. Because the results comprise the new knowledge that you are contributing to the world, it is important that your findings be clearly and simply stated.

The results should be short and sweet. Do not say "It is clearly evident from Fig. 1 that bird species richness increased with habitat complexity". Say instead "Bird species richness increased with habitat complexity (Fig. 1)".

However, don't be too concise. Readers cannot be expected to extract important trends from the data unaided. Few will bother. Combine the use of text, tables and figures to condense data and highlight trends. In doing so be sure to refer to the guidelines for preparing tables and figures below.

Discussion

In the discussion you should discuss what principles have been established or reinforced; what generalisations can be drawn; how your findings compare to the findings of others or to expectations based on previous work; and whether there are any theoretical/practical implications of your work.

When you address these questions, it is crucial that your discussion rests firmly on the evidence presented in the results section. Refer briefly to your results to support your discussion statements. Do not extend your conclusions beyond those that are directly supported by your results.

A brief paragraph of speculation about what your results may mean in a general sense is usually acceptable, but should not form the bulk of the discussion. Be sure to address the objectives of the study in the discussion and to discuss the significance of the results. Don't leave the reader thinking "So what?" End the discussion with a short summary or conclusion regarding the significance of the work.

References

Whenever you draw upon information contained in another paper, you must acknowledge the source. All references to the literature must be followed immediately by an indication of the source of the information that is referenced, for example, "A drop in dissolved oxygen under similar conditions has been demonstrated before (Norris, l986)."

If two authors are involved, include both surnames in this reference. However if more authors are involved, you may use 'et al', an abbreviation of Latin meaning 'and others'. In general you should not use the abbreviation in the full reference at the end of the article, although some journals permit this. If two more articles written by the same author in the same year are cited, most journals ask you to add suffixes 'a', 'b' etc in both the text and the reference list.

If you include in your report phrases, sentences or paragraphs repeated verbatim from the literature, it is not sufficient to simply cite the source. You must include the material in quotes and you must give the number of the page from which the quote was lifted. For example: "Day (l979: 3l) reports a result where '33.3% of the mice used in this experiment were cured by the test drug; 33.3% of the test population were unaffected by the drug and remained in a moribund condition; the third mouse got away'".

A list of references ordered alphabetically by author's surname, or by number, depending on the publication, must be provided at the end of your paper. The reference list should contain all references cited in the text but no more. Include with each reference details of the author, year of publication, title of article, name of journal or book and place of publication of books, volume and page numbers.

Formats vary from journal to journal, so when you are preparing a scientific paper for an assignment, choose a journal in your field of interest and follow its format for the reference list. Be consistent in the use of journal abbreviations.

Appendices

Appendices contain information in greater detail than can be presented in the main body of the paper, but which may be of interest to a few people working specifically in your field. Only appendices referred to in the text should be included.

Formatting conventions

Most publications have guidelines about submission and manuscript preparation, for online or mailed submissions. Most journals require the manuscript to be typed with double spacing throughout and reasonable margins. Make sure you read the guide to authors before submitting your paper so that you can present your paper in the right format for that publication (refer to submission of paper article in this series).

Finally — and perhaps most importantly — ALWAYS read the journal's guide to authors before submitting a paper, and ALWAYS provide an informative cover letter to your submission.

Constructing tables

Include a caption and column headings that contain enough information for the reader to understand the table without reference to the text. The caption should be at the head of the table. Organise the table so that like elements read down, not across.

Present the data in a table or in the text, but never present the same data in both forms. Choose units of measurement so as to avoid the use of an excessive number of digits.

Don't include tables that are not referred to in the text, or be tempted to 'dress up' your report by presenting data in the form of tables or figures that could easily be replaced by a sentence or two of text.

Don't include columns of data that contain the same value throughout. If the value is important to the table include it in the caption or as a footnote to the table.

Don't use vertical lines to separate columns unless absolutely necessary.

Constructing figures

Include a legend describing the figure. It should be succinct yet provide sufficient information for the reader to interpret the figure without reference to the text. The legend should be below the figure.

Provide each axis with a brief but informative title (including units of measurement).

Don't include figures that are not referred to in the text, or be tempted to 'dress up' your report by presenting data in the form of figures that could easily be replaced by a sentence or two of text.

Don't fill the entire A4 page with the graph leaving little room for axis numeration, axis titles and the caption. The entire figure should lie within reasonable margins (say 3 centimetre margin on the left side, 2 centimetre margins on the top, bottom and right side of the page).

Don't extend the axes very far beyond the range of the data. For example, if the data range between 0 and 78, the axis should extend no further than a value of 80.

Don't use colour, unless absolutely necessary. It is expensive, and the costs are usually passed on to the author. Colour in figures may look good in an assignment or thesis, but it means redrawing in preparation for publication.

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This article was previously part of SciDev.Net's e-guide to science communication and has been reformatted to become this practical guide.

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